FP5530

Dual H-Bridge Motor Driver

Description

The FP5530 provides a dual bridge motor driver for driving two brush motors, a bipolar stepper motor, solenoids, or other inductive loads.

The output driver block of each H-bridge consists of a P-channel and N-channel power MOSFETs configured as an H-bridge to drive the motor windings. Each H-bridge includes circuitry to regulate or limit the winding current.

The FP5530 fault protection includes over current limit, short circuit protection, UVLO and thermal shutdown. In sleep mode, the supply current is about 1.6μA.

The FP5530 is offered in 16 pin TSSOP and TQFN packages with exposed pad, which provides good thermal conductance.

Features

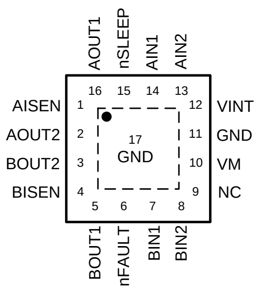
- Dual H-Bridge Current Control
  Driver Two DC Motors or One Stepper Motor
- Low $R_{DS(ON)}$ Integrated Power MOSFET
  HS+LS: 1735mΩ
- Output Current Capability (At VM = 5V, 25℃)
  TSSOP Package
  -0.7A RMS, 1A Peak per H-bridge
  -1.4A RMS in Parallel Mode
  TQFN Package
  -0.6A RMS, 1A Peak per H-bridge
  -1.2A RMS in Parallel Mode
- Wide Input Voltage Range: 2.7V to 10.8V
- Low current in sleep mode: 1.6uA
- Input Under Voltage Lockout
- PWM Winding Current control and limited
- Over-Temperature Protection with Auto Recovery
- High power 16-pin TSSOP and TQFN (3mm x 3mm) packages

Applications

- POS Printers/Office Automation Machines
- Video Security Cameras
- Gaming Machines/Robotics/Battery-Powered Toys

Pin Assignments

W3 Package (TQFN-16)(3mm x 3mm)



A3 Package(TSSOP-16) (5.1mm x 6.6mm)

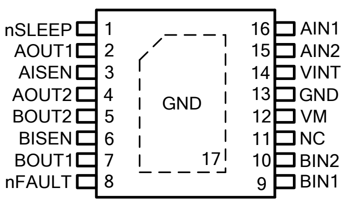


Figure 1. Pin Assignments of FP5530

Ordering Information

FP5530□

Package Type
A3: TSSOP-16(Exposed Pad)
W3: TQFN-16(3mm x 3mm)

Typical Application Circuit

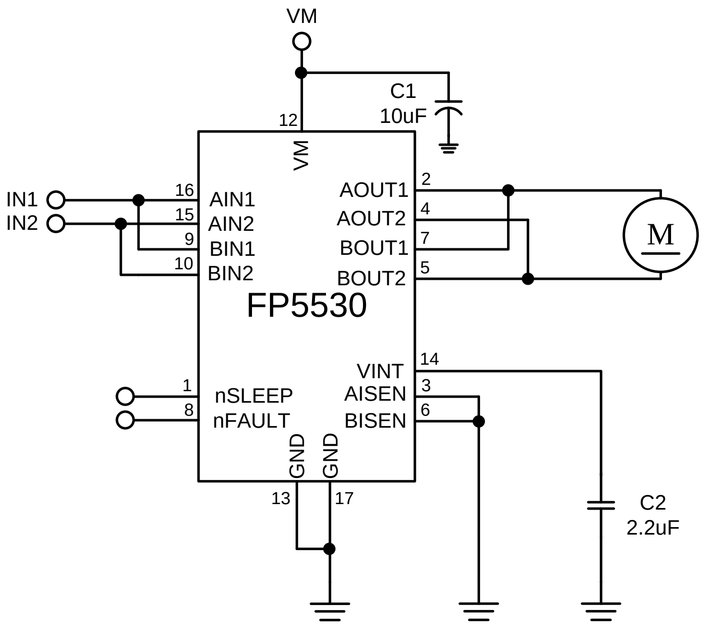


Figure 2. DC Motor Parallel Mode Application Circuit for TSSOP Package

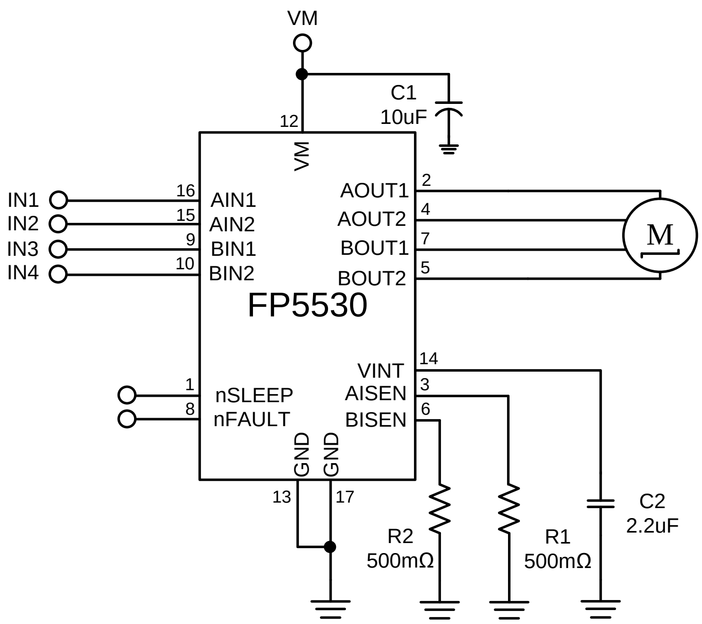


Figure 3. Step Motor Application Circuit for TSSOP Package

Functional Pin Description

Pin Name	TQFN Pin No.	TSSOP Pin No.	Pin Function
AISEN	1	3	Isense. Connect to current sense resistor for bridge A, or GND if current control not needed.
AOUT2	2	4	Bridge A output 2.
BOUT2	3	5	Bridge B output 2.
BISEN	4	6	Isense. Connect to current sense resistor for bridge B or GND if current control not needed.
BOUT1	5	7	Bridge B output 1.
nFAULT	6	8	Fault indication pin. Logic low when it into fault condition.
BIN1	7	9	Bridge B input 1. Logic input controls state of AOUT1. Internal pull-down.
BIN2	8	10	Bridge B input 2. Logic input controls state of AOUT1. Internal pull-down.
NC	9	11	NC
VM	10	12	Device power voltage. Connect motor supply. A 10uF ceramic bypass capacitor to GND is recommended.
GND	11,17	13, 17	Ground pin.
VINT	12	14	Internal supply bypass to GND with 2.2uF ceramic capacitor.
AIN2	13	15	Bridge A input 2. Logic input controls state of AOUT1. Internal pull-down.
AIN1	14	16	Bridge A input 1. Logic input controls state of AOUT1. Internal pull-down.
nSLEEP	15	1	Sleep mode. Logic high to enable device, logic low to enter low power sleep mode and reset all internal logic. Internal pull-down.
AOUT1	16	2	Bridge A output 1.

Block Diagram

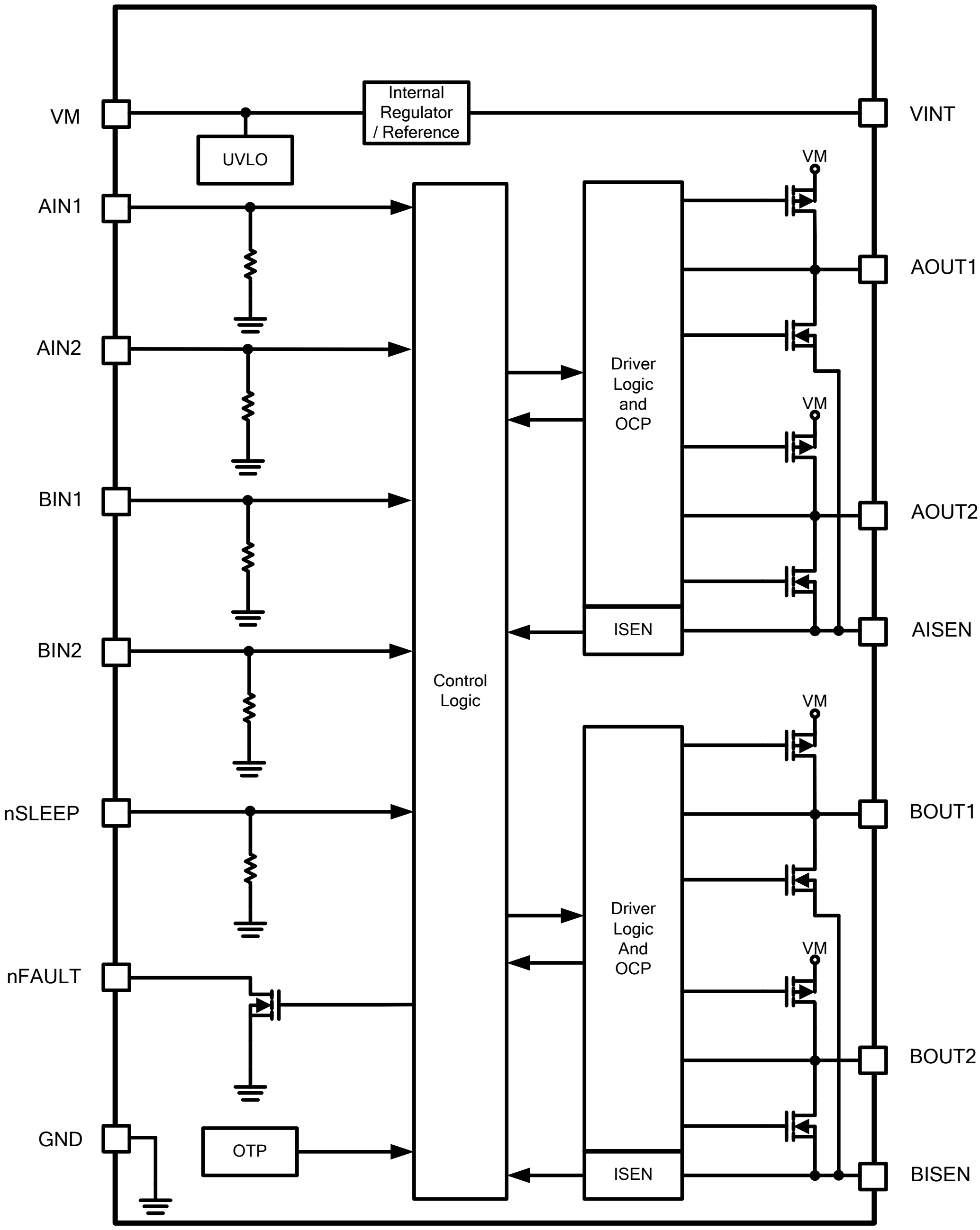


Figure 4. Block Diagram of FP5530

Absolute Maximum Ratings (Note 1)

- Supply Voltage V_{IN} -- -0.3V to +11.5V
- Internal regulator VINT -- -0.3V to +6V
- Digital input pin voltage-- -0.3V to +7V
- Continuous phase node pins--- -0.3V to VM+0.5V
- Pulsed 10us phase node pins--- -1 to VM+1V
- Continuous shunt amplifier input pins--- -0.3V to +0.5V
- Pulsed 10us phase input pins--- -1 to +1V
- Peak motor driver output current-- Internally limited
- Maximum Junction Temperature (T_J) -- -40°C to +150°C
- Package Thermal Resistance, (θ_{JA})

  TSSOP-16--- 54°C/W

  TQFN -- 68°C/W
- Package Thermal Resistance, (θ_{JC})

  TSSOP-16--- 20°C/W

  TQFN -- 46°C/W

Note 1: Stresses beyond this listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Motor power supply voltage range-- +2.7V to +10.8V
- Digital input pin voltage range--- 0 to +5.5V
- Motor RMS current (TSSOP package)-- 0 to 0.7A
- Motor RMS current (TQFN package)-- 0 to 0.6A
- Applied PWM signal to xINx--- 0 to 200kHz
- Operation Temperature Range -- -40°C to +85°C

Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Power Supply						
VM operating voltage	V_M		2.7		10.8	V
VM operating supply current	I_{VM}	VM=5V,xINx=low, nSLEEP=H		1.7	3	mA
VM sleep mode supply current	I_{VMQ}	VM=5V, nSLEEP=L		1.6	2.7	uA
Sleep time	t_{SLEEP}	nSLEEP=L to sleep mode		10		us
Wake up time	t_{WAKE}	nSLEEP=H to output transition		155		us
Turn on time	t_{ON}	V_M>UVLO to output transition		25		us
Internal regulator voltage	VINT	V_M		5		V
Logic-Level Inputs						
Input low voltage	V_{IL}	nSLEEP			0.7	V
		xINx			0.5	
Input high voltage	V_{IH}	nSLEEP	2		5.5	V
		xINx	2.5		5.5	
Input hysteresis	V_{HYS}		0.35	0.4	0.65	V
Input pulldown resistance	R_{PD}	nSLEEP	380	500	750	kΩ
		xINx	100	150	250	
Input low current	I_{IL}	VIN=0V	-1		1	uA
Input high current	I_{IH}	VIN=5V			50	uA
Input deglitch current	t_{DEG}			575		ns
Propagation delay Inx to OUTx	t_{PROP}	V_M=5V		1.2		us
nFAULT Output (Open-Drain Output)						
Output low voltage	V_{OL}	Io=5mA			0.5	V
Output high leakage current	I_{OH}	R_{PULLUP}=1kΩ to 5V	-1		1	uA
Current Control						
xISEN trip voltage	V_{TRIP}		160	200	240	mV
Current control constant off time	t_{off}	Internal PWM constant off time		20		us

Electrical Characteristics (Continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Motor Driver Outputs (xOUTx)						
HS FET on resistance	HS,Rds(on)	VM=5V, Io=200mA, Tj=25℃		1180		mΩ
		VM=2.7V ,Io=200mA, Tj=85℃ (Note 2)		1550		mΩ
LS FET on resistance	LS,Rds(on)	VM=5V, Io=200mA, Tj=25℃		555		mΩ
		VM=2.7V, Io=200mA, Tj=85℃ (Note 2)		635		mΩ
Off-state leakage current	I_{OFF}	VM=5V, Tj=25℃, Vout=0V	-1		1	uA
Rise time	t_R	VM=5V, 16Ω to GND		70		ns
Fall time	t_F	VM=5V, 16Ω to VM		80		ns
Dead time	t_{DEAD}	internal dead time		450		ns
Protection Circuits						
VM under voltage lockout	V_{UVLO}	VM falling; UVLO report			2.6	V
		VM rising; UVLO recovery			2.7	V
VM under voltage lockout hysteresis	$V_{UVLO,HYS}$	Rising to falling threshold		90		mV
Over current protection trip level	I_{OCP}		1			A
OCP deglitch time	t_{DEG}			2.3		us
Over urrent protection period	t_{OCP}			1.4		ms
Thermal shutdown temperature (Note 2)	t_{TSD}	Die temperature	150			°C

Note 2: Not production tested.

Function Description

The FP5530 is an integrated motor driver for brushed DC and bipolar stepper motors. The device integrated two PMOS+NMOS H-bridge and current regulation circuitry. The FP5530 can be powered with a supply voltage from 2.7V to 10.8V and can provide an output current up to 700mA RMS, and including the PWM interface allows easy interfacing to the controller circuit, a fixed off time slow decay, a low power sleep mode, which lets the system save power when not driving the power.

Bridge Control and Decay Modes

The AIN1 and AIN2 input pins control the state of the AOUT1 and AOUT2 outputs, the BIN1 and BIN2 input pins control the state of the BOUT1 and BOUT2 outputs. Table 1 shows the logic.

xIN1	xIN2	xOUT1	xOUT2	FUNCTION
0	0	Z	Z	Coast/Fast decay
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake/Slow decay

Table 1. H-Bridge Logic

The inputs can also be used for PWM control of the motor speed. When controlling a winding with PWM, when the drive current is interrupted, the inductive nature of the motor requires that the current must continue to flow. This is called recirculation current. To handle this recirculation current, the H-bridge can operate in two different states: fast decay or slow decay. In fast decay mode, the H-bridge is disabled and recirculation current flows through the body diodes, in slow decay, the motor winding is shorted.

To PWM using fast decay, the PWM signal is applied to one xIN pin while the other is held low, to use slow decay, one xIN pin is held high.

xIN1	xIN2	FUNCTION
PWM	0	Forward PWM/Fast decay
1	PWM	Forward PWM/Slow decay
0	PWM	Reverse PWM/Fast decay
PWM	1	Reverse PWM/Slow decay

Table 2. PWM control of Motor Speed

Current Control

The current through the motor windings may be limited, or controlled, by a 20us constant off time PWM current regulation, or current chopping. For DC motors, current control is used to limit the start up and stall current of the motor. For stepper motors, current control is often used at all times. When an H-bridge is enabled, current rises through the winding at a rate dependent on the DC voltage and inductance of the winding. If the current reaches the current chopping threshold, the bridge disables the current until the beginning of the next PWM cycle. Immediately after the current is enabled, the voltage on the xISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is fixed at 3.75us. This blanking time also sets the minimum on time of the PWM when operating in current chopping mode. The PWM chopping current is set by a comparator which compares the voltage across a current sense resistor connected to the xISEN pins with reference voltage. The reference voltage is fixed at 200mV nominally.

The chopping current is the maximum current driven through either winding. The quantity depends on the sense resistor value(R_{XISEN})
The chopping current is calculated in Equation.

$$I_{CHOP}=\frac{200mV}{R_{ISENSE}}$$

Decay Mode

After the chopping current threshold is reached, the H-bridge switches to slow decay mode. This state is held for current chopping blanking time (20us) until the next cycle to turn on the high side MOSFETs.

Slow Decay

In slow decay, the high side MOSFETs are turned off and both of the low side MOSFETs are turned on. The motor current decrease while flowing in the two low side MOSFETs until reaching its fixed off time (typically 20us). After off time, the high side MOSFETs are enable to increase the winding current again.

Function Description (Continued)

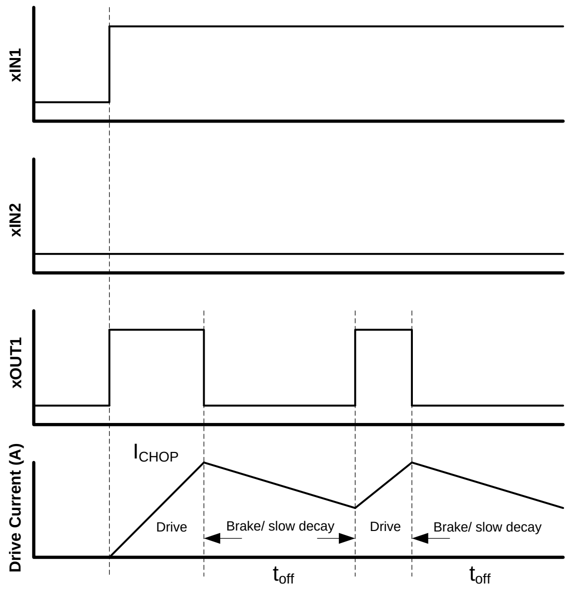


Figure 5. Current Chopping Operation

Sleep Mode operation

Driving nSLEEP low will put the device into a low power sleep state. In this state, the H-bridges are disabled, the gate drive charge pump is stopped, all internal logic is reset, and all internal clocks are stopped. All inputs are ignored until nSLEEP returns inactive high. When returning from sleep mode, some time, t_{WAKE}, needs to pass before the motor driver becomes fully operational. To make the board design simple, the nSLEEP can be pulled up to the supply (VM). Recommends using a pull up resistor when this is done. This resistor limits the current to the input case VM is higher than 6.5V. Internally, the nSLEEP pin has 500kΩ resistor to GND. It also has a clamping Zener diode that clamps the voltage at the pin at 6.5V. Current greater than 250uA can cause damage to the input structure. Hence the recommended pull up resistor would be between 20kΩ and 75kΩ.

Input Under Voltage Lockout

When the FP5530 is power on, the internal circuits are held inactive until V_M voltage exceeds the input UVLO threshold voltage. And the regulator will be disabled when V_M is below the input UVLO threshold voltage. nFAULT is driven low in the event of an under voltage condition.

Over Current Protection

An analog current limit circuit on each FET limits the current through the FET by limiting the gate drive. If this analog current limit persists for longer than the OCP deglitch time, all FETs in the H-bridge will be disable and the nFAULT pin will be driven low. The driver will be re-enabled after the OCP retry period (t_{OCP}) has passed. nFAULT becomes high again at this time. If the fault condition is still present, normal operation resumes and nFAULT remains deasserted. Please note that only the H-bridge in which the OCP is detected will be disabled while the other bridge will function normally.

Over current conditions are detected independently on both high and low side devices. When the device occur a short to ground, supply, or across the motor winding will all result in an over current shutdown. Over current protection does not use the current sense circuitry used for PWM current control, so it functions even without presence of the xISEN resistors.

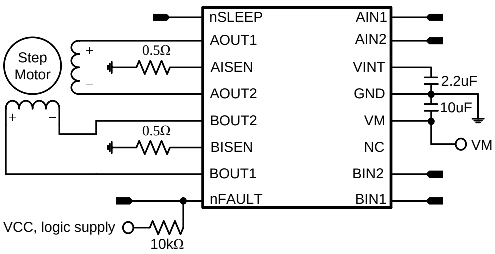
Over Temperature Protection

The FP5530 incorporates an over temperature protection circuit to protect itself from overheating. When the junction temperature exceeds the thermal shutdown threshold temperature, all FETs in the H-bridge will be disable and nFault pin will be driven low. Once the die temperature has fallen to a safe level, operation will automatically resumed.

Application Information

The FP5530 is used in bipolar stepper motor or brushed DC motor control. The following description which can be used to FP5530 in a bipolar stepper motor application.

Typical Application Circuit



Design Requirements

Table 3 gives input parameters for system design

Design Parameter	Reference	Example Value
Supply voltage	V_M	8.4V
Motor winding resistance	R_L	10Ω/phase
Motor winding inductance	L_L	4mH/phase
Motor full step angle	θ_{step}	1.8° /step
Target stepping level	n_m	2 (half-stepping)
Target motor speed	v	120rpm
Target chopping current	I_{CHOP}	400mA
Sense resistor	R_{ISEN}	0.5Ω

Table 3. Design Parameters

Design Procedure

Stepper Motor Speed

The first step in configuring the FP5530 requires the desired motor speed and stepping level. The FP5530 can support full and half stepping modes using the PWM interface.

If the target motor speed is too high, the motor does not spin. Ensure that the motor can support the target speed.

For a desired motor speed (v), microstepping level (n_m), and motor full step angle (θ_{step}),

$$f_{step}(step/s) = \frac{v(rpm) \times n_m(steps) \times 360°/rot}{Q_{step}(°/step) \times 60s/min}$$

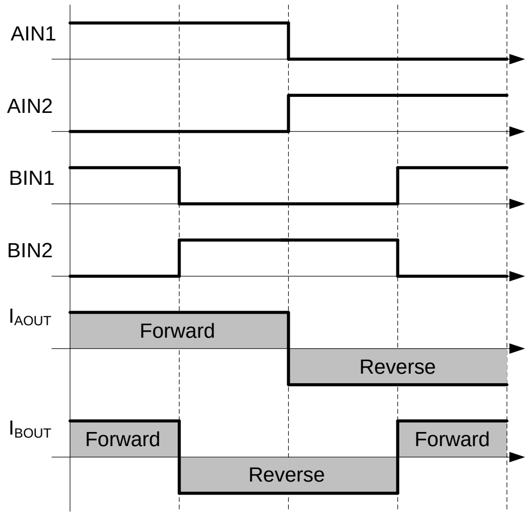


Figure 6. Full Step Mode

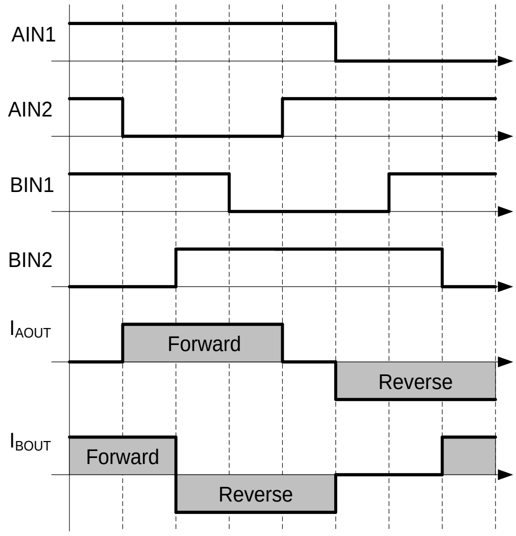


Figure 7. Half Step Mode

The chopping current (I_{CHOP}) is the maximum current driven through either winding. This quantity depends on the sense resistor value (R_{XISEN}).

$$I_{CHOP} = \frac{200mV}{R_{XISEN}}$$

I_{CHOP} is set by a comparator the voltage across R_{XISEN} to reference voltage. Note that I_{CHOP} must follow equation to avoid saturation motor.

$$I_{FS}(A) < \frac{VM(V)}{R_L(\Omega) + R_{DS(ON),HS}(\Omega) + R_{DS(ON),LS}(\Omega)}$$

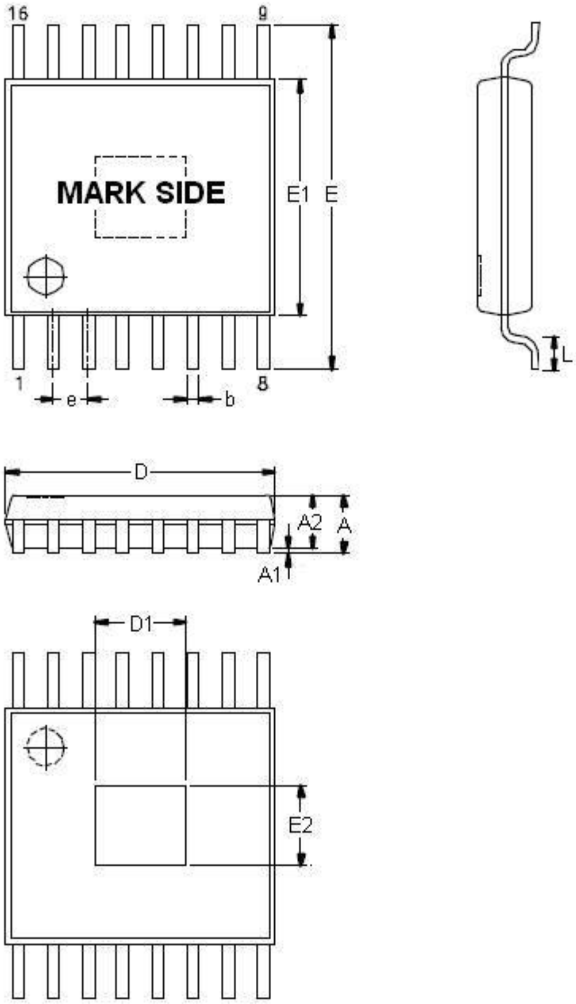
Where

V_M is the motor supply voltage.

R_L is the motor winding resistance.

Outline Information

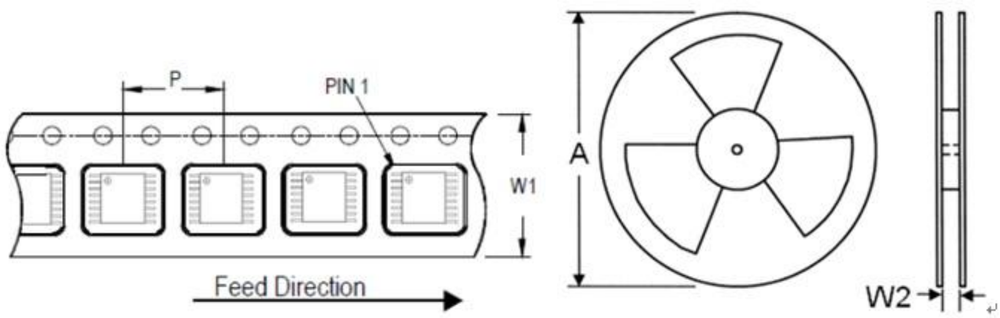
TSSOP-16 EP Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.80	1.20
A1	0.00	0.15
A2	0.80	1.05
b	0.19	0.30
D	4.90	5.10
E1	4.30	4.50
E	6.20	6.60
e	0.55	0.75
L	0.45	0.75
D1	1.98	3.00
E2	1.98	3.00

Note 3: Followed From JEDEC MO-153-F.

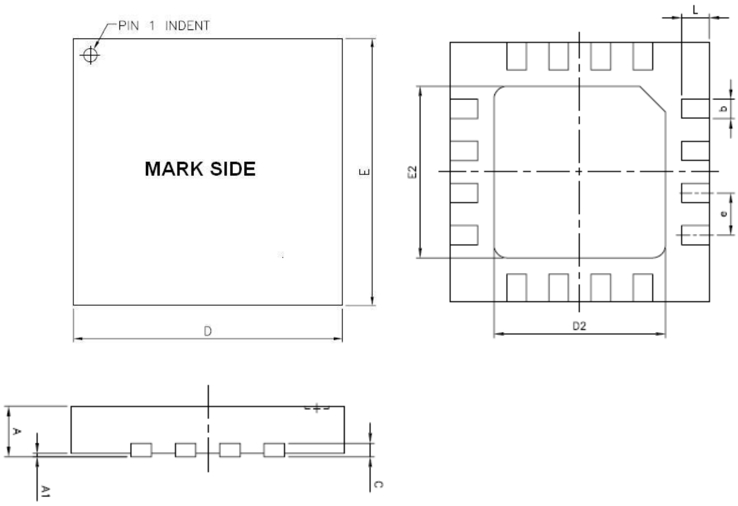
Carrier Dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
12	8	13	330	12.4	240~1120	2,500

Outline Information (Continued)

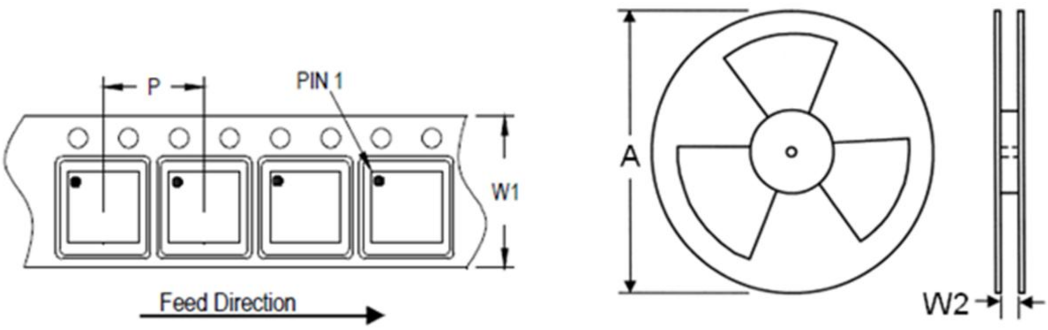
TQFN- 16 3mm×3mm (pitch 0.5mm) Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
C	0.19	0.30
E	2.90	3.10
D	2.90	3.10
L	0.35	0.45
b	0.18	0.30
e	0.5 BSC	
E2	1.55	1.80
D2	1.55	1.80

Note4: Followed From JEDEC MO-220.

Carrier Dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
12	8	13	330	12.4	400~1000	3,000

Life Support Policy
Fitipower's products are not authorized for use as critical components in life support devices or other medical systems.